An opportunity is thus offered to a donor to have his name permanently attached to a refracting telescope, which, besides being the largest in the world, would be more favorably situated than almost any other, and would have a field of work comparatively new. The numerous gifts to this Observatory by residents of Boston and its vicinity prevent the request for a general subscription; but it is believed that if the matter is properly presented, some wealthy person may be found who would gladly make the requisite gift, in view of the strong probability that it will lead to a great advance in our knowledge of the heavenly bodies. Any one interested in this plan is invited to address the author of this article.

CAMBRIDGE, Mass., U. S. A., September, 1892.

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## ON THE RADIANT POINTS OF METEOR-SHOWERS.

BY W. H. S. MONCK, F. R. A. S.

The earlier observers of meteor-showers usually regarded them as of considerable duration, without any material change in the radiant. It was not until the connexion of certain showers with comets was pointed out that a shorter duration was generally adopted as agreeing best with the mathematical theory of the subject. But practical observers can hardly be said to have ever adopted the short-duration theory, and Mr. DENNING began to impugn it openly not long after the theory of SCHIAPARELLI had been generally adopted. In this he was supported by the late Mr. R. P. GREG, who held, in spite of theory, that the average duration of a meteor-shower was at least three weeks. I am not aware that Mr. DENNING has anywhere expressed an opinion as to the average duration, or as to whether stationary or long-enduring showers constitute the rule or the exception, but he seems to have established the existence of many such showers extending considerably beyond Mr. GREG'S three weeks. The object of the present paper is to show that stationary and long-enduring radiants are the rule, not the exception, and that the mathematical theory of the subject must to a considerable extent be recast in order to account for them. I shall endeavor to show this by an analysis of the radiants comprised in the first quadrant

of Right Ascension in Mr. DENNING'S great Catalogue of 918, or rather 920, radiants in the *Monthly Notices* of the R. A. S. for May, 1890. The order which I follow is that of Right Ascension, varied only to show the grouping round particular points. In giving the dates I include those contained in the column "Other Nights of Observation." In the column headed "Position of Radiant," the first figure represents the Right Ascension, and the second the Declination of the radiant point, the sign — being used to indicate South Declination. The list will, I think, be found complete as far as it goes.

| Position of Radiant. | Date. |
|---|---|
| 0°+53° | Aug. 8–14 |
| 1°+63° | Sept. 15 |
| 1°— 5° | Aug. 20–28 |
| 4°— 2° | Sept. 3–5 |
| 3°+27° | Aug. 7 |
| 4°+20° | Aug. 3–7 |
| 5°+17° | Aug. 21–23 |
| 5°+10° | July 27–Aug. 1 |
| 5°+10° | Aug. 23–25 |
| 5°+10° | Sept. 13–22 |
| 5°+11½° | Sept. 12–15 |
| 5°+12° | Aug. 21–24 |
| 5°+12° | Aug. 17–20 |
| 6°+11° | July 12–13 |
| 7°+10° | Sept. 22 |
| 7°+11° | July 31–Aug. 1 |
| 7°+11° | Aug. 2–10 |
| 3°+35° | July 26 |
| 4°+35° | July 7 |
| 5°+35° | July 11 |
| 5°+35° | July 16 |
| 5°+35° | Aug. 20–22 |
| 6°+34° | July 27 |
| 6°+35° | July 30 |
| 6°+37° | Aug. 10 |
| 7°+35° | Oct. 1–7 |
| 7°+36° | July 28 |
| 7°+37° | July 12 |
| 7°+37° | July 29 |
| 8°+33° | Aug. 8–14 |
| 8°+35° | Oct. 8–14 |
| 8°+38° | Aug. 12 |
| 10°+37° | Aug. 16 |
| 10°+38° | Aug. 12 |
| 13°+38° | Sept. 10–17 |
| 3°+49° | July 8–11 |
| 5°+52° | July 16 |
| 5°+52° | Nov. 10–13 |
| 5°+54° | Aug. 14–21 |
| 7°+51° | Oct. 15–20 |
| 7°+53° | July 17 |
| 8°+52° | July 26–30 |
| 8°+53° | Aug. 10–12 |
| 7°+44° | Sept. 13–24 |
| 8°+45° | Aug. 21–24 |
| 11°+47° | July 31–Aug. 1 |
| 11°+48° | July 11–14 |
| 10°± 0° | Sept. 12 |
| 11°+ 8° | Oct. 19–21 |
| 13°+ 6° | Oct. 11 |
| 13°+ 6° | Sept. 13–17 |
| 14°+12° | Sept. 22–30 |
| 12°+52° | July 25–30 |
| 14°+50° | Sept. 18–21 |
| 14°+50° | Oct. 13–15 |
| 16°+54° | Sept. 4–5 |
| 17°+53° | Nov. 7–18 |
| 19°+51° | July 19 |

| Position of Radiant. | Date. |
|---|---|
| 12°+70° | July 25–Aug. 1 |
| 16°+31° | July 22–Aug. 1 |
| 16°+31° | Aug. 19–24 |
| 16°+33° | Sept. 22–27 |
| 19°+30° | Nov. 5–10 |
| 18°+58° | July 28 |
| 20°+58° | May 30 |
| 20°+58° | Aug. 2–4 |
| 20°+56° | Sept. 13–22 |
| 21°+57° | July 20–Aug. 1 |
| 21°+55° | Oct. 14 |
| 18°+63° | July 19–24 |
| 18°+63° | Aug. 7–12 |
| 20°+65° | July 22–Aug. 1 |
| 20°+ 8° | July 30 |
| 20°+ 8° | Sept. 16 |
| 20°+14° | Sept. 19 |
| 21°+14° | Oct. 13–19 |
| 23°+17° | Oct. 5–7 |
| 21°+22° | July 28 |
| 21°+23° | July 5–6 |
| 21°+42½° | Nov. 30 |
| 22°+43½° | Nov. 28 |
| 22°+46° | Aug. 12–16 |
| 23°+41° | July 27–Aug. 1 |
| 24°+42° | Aug. 21–25 |
| 24°+44° | Nov. 27 |
| 24°+45° | Nov. 22–26 |
| 25°+42° | Aug. 19–21 |
| 25°+44° | Oct. 14–15 |
| 25°+46° | Nov. 4–7 |
| 26°+42° | Aug. 4–10 |
| 26°+44° | Nov. 26 |
| 28°+45° | Sept. 4–16 |
| 29°+46° | Nov. 27 |
| 30°+46° | Aug. 11–13 |
| 31°+49° | Aug. 6 |
| 23°+30° | Aug. 14–24 |
| 28°+28° | July 27–31 |

| Position of Radiant. | Date. |
|---|---|
| 28°+30° | July 11–13 |
| 23°+36° | Aug. 8–13 |
| 24°+36° | Oct. 14 |
| 25°+52° | July 22 |
| 25°+52° | July 23 |
| 27°+55° | July 28 |
| 29°+54° | July 27 |
| 30°+55° | July 28 |
| 31°+52° | Sept. 21–25 |
| 31°+54½° | July 29 |
| 32°+50° | Oct. 8 |
| 32°+50° | Aug. 14–23 |
| 32°+53° | July 27–28 |
| 32°+53° | July 28 |
| 32°+53° | July 30–Aug. 1 |
| 33°+54° | Sept. 6–9 |
| 33°+55° | Aug. 2 |
| 35°+54° | July 31 |
| 35°+54° | Aug. 2 |
| 36°+56° | Aug. 1 |
| 37°+57° | Aug. 4 |
| 25°+71° | Sept. 12–17 |
| 25°+71° | Sept. 30–Oct. 2 |
| 25°+71° | Oct. 4–8 |
| 26°+70° | Aug. 25 |
| 26°+72° | Aug. 21–30 |
| 26°+72° | Oct. 29–Nov. 7 |
| 27°+71° | Nov. 29–30 |
| 27°+71° | Nov. 28–Dec. 1 |
| 28°+70° | Dec. 9–10 |
| 28°+72° | Sept. 12–22 |
| 29°+72° | Oct. 11–21 |
| 32°+70° | Oct. 13–15 |
| 28°+36° | July 26–31 |
| 29°+37° | Nov. 4–10 |
| 30°+36° | Aug. 4–10 |
| 30°+36° | Sept. 14–15 |
| 30°+36° | Sept. 22–27 |
| 30°+36° | Sept. 21–25 |

| Position of Radiant. | Date. |
|---|---|
| 30°+36° | Oct. 5–8 |
| 30°+36½° | Aug. 25 |
| 31°+37° | Oct. 13–19 |
| 31°+37° | Nov. 30–Dec. 7 |
| 30°+16° | Nov. 4–7 |
| 31°+18° | July 30 |
| 31°+18° | Aug. 12 |
| 31°+18° | Oct. 7–8 |
| 31°+19° | Sept. 21–25 |
| 32°+17° | Aug. 2–4 |
| 32°+19° | Sept. 27–Oct. 2 |
| 34°+18° | July 27–31 |
| 34°+18° | Oct. 17–18 |
| 34°+19° | Sept. 20–24 |
| 38°+20° | Nov. 2–3 |
| 40°+20° | Oct. 12–24 |
| 31°+ 8° | Oct. 7 |
| 31°+ 9° | Oct. 14–15 |
| 32°+ 8° | Nov. 3 |
| 38°+12° | Oct. 14–25 |
| 40°+10° | Nov. 4–9 |
| 33°—20° | July 28 |
| 37°—13° | Nov. 28–Dec. 10 |
| 36°+47° | July 12 |
| 39°+28° | Aug. 18–21 |
| 40°+28° | Aug. 3–12 |
| 40°+29° | Oct. 11–15 |
| 40°+72° | Sept. 4–16 |
| 40°+77° | Oct. 31 |
| 40°+40° | Sept. 20 |
| 41°+38° | Sept. 17–19 |
| 41°+39° | Nov. 28–30 |
| 42°+38½° | Oct. 12–15 |
| 43°+39° | July 29–31 |
| 43°+39° | Aug. 23–25 |
| 43°+ 7° | Sept. 18–26 |
| 43°+ 5° | Oct. 22 |
| 45°+ 6° | Oct. 20 |
| 43°+21° | Oct. 31 |

| Position of Radiant. | Date. |
|---|---|
| 43°+23° | Nov. 1–7 |
| 46°+26° | July 22–31 |
| 46°+26° | Oct. 14–17 |
| 46°+23° | Sept. 7–9 |
| 46°+21° | Nov. 12–14 |
| 47°+28° | Oct. 8 |
| 48°+21° | Nov. 2–3 |
| 47°+16° | Oct. 7–8 |
| 49°+14° | Sept. 7–16 |
| 49°+31° | July 30–Aug. 2 |
| 50°+31° | Sept. 16–19 |
| 45°+46° | Oct. 15–20 |
| 46°+45° | Aug. 7–10 |
| 46°+44° | Aug. 19–21 |
| 46°+43° | Aug. 14–30 |
| 46°+47° | Aug. 21–23 |
| 47°+45° | Feb. 23–Mar. 12 |
| 47°+45° | July 20 |
| 47°+45° | Oct. 5–8 |
| 47°+45° | Sept. 15–16 |
| 47°+44° | Oct. 17–23 |
| 47°+44° | Dec. 28–Jan. 11 |
| 48°+42° | Nov. 27–Dec. 8 |
| 48°+43° | July 21–27 |
| 48°+43° | Aug. 2–10 |
| 48°+43° | Nov. 12–14 |
| 48°+43½° | Sept. 9–15 |
| 48°+44° | Aug. 19–21 |
| 48°+44° | Sept. 22–27 |
| 39°+55° | Aug. 2 |
| 40°+56° | June 14–25 |
| 40°+56° | Aug. 3 |
| 40°+56° | Aug. 7 |
| 40°+59° | Aug. 20–21 |
| 41°+55° | Aug. 7 |
| 41°+55° | Aug. 8 |
| 41°+58° | Aug. 7 |
| 42°+55° | Aug. 6 |
| 42°+55° | Oct. 6–16 |

| Position of Radiant. | Date. |
|---|---|
| 42°+57° | Aug. 5 |
| 42°+57° | Aug. 8 |
| 42½°+54° | Aug. 10 |
| 42½°+57½° | Aug. 10 |
| 43°+56° | Aug. 7 |
| 43°+56° | Aug. 8 |
| 43°+57° | Aug. 10 |
| 43°+58° | July 27–31 |
| 43°+58° | Aug. 10 |
| 43°+58° | Oct. 8–14 |
| 44°+55° | Aug. 9 |
| 44°+56° | Nov. 29 |
| 44°+56° | Dec. 1–10 |
| 44°+57° | Aug. 10 |
| 44°+58½° | Aug. 10 |
| 44°+59° | Aug. 10 |
| 44°+59° | Aug. 10 |
| 45°+57° | Aug. 10 |
| 45°+57½° | Aug. 11 |
| 45°+60° | Nov. 5–7 |
| 46°+57° | Aug. 11 |
| 46°+58° | Aug. 9–12 |
| 47°+57° | Aug. 11 |
| 48°+57° | Aug. 11 |
| 48°+57° | Aug. 12 |
| 49½°+57°½ | Aug. 13 |
| 50°+55° | Aug. 12 |
| 50°+54° | Sept. 14 |
| 51°+58° | Aug. 13 |
| 52°+57° | Aug. 13 |
| 53°+57° | Aug. 14 |
| 47°+65° | Dec. 15–29 |
| 48°+63° | Sept. 6–7 |
| 48°+60° | Oct. 14 |
| 53°+64° | Sept. 5–7 |
| 54°+48° | Nov. 27 |
| 56°+52° | Oct. 5–8 |
| 60°+59° | Aug. 16 |
| 50°+75° | July 21–23 |

| Position of Radiant. | Date. |
|---|---|
| 50°+85° | Oct. 1–3 |
| 53°+71° | Nov. 16–18 |
| 54°+71° | Aug. 14–21 |
| 54°+71° | Oct. 5–6 |
| 54°+71° | Oct. 14–23 |
| 55°+71° | Sept. 15–24 |
| 55°+ 9° | Nov. 2–3 |
| 59°+ 9° | Sept. 15–16 |
| 62°+ 9° | Nov. 4 |
| 57°—12° | Jan. 4–8 |
| 57°+18° | Nov. 1–7 |
| 58°+16° | Nov. 7–8 |
| 58°+21° | Nov. 13–14 |
| 61°+18° | Oct. 21–29 |
| 59°+49° | Sept. 21–22 |
| 60°+48° | Aug. 10–16 |
| 60°+49° | Nov. 28–Dec. 10 |
| 60°+50° | Aug. 21–24 |
| 61°+48° | Aug. 16 |
| 61°+48° | Sept. 4–7 |
| 61°+48° | Sept. 15 |
| 61°+48° | Sept. 14–21 |
| 61°+48° | Nov. 13–14 |
| 61°+47° | Oct. 8–17 |
| 61°+49° | Sept. 5–7 |
| 61°+49° | Nov. 4–9 |
| 61°+50° | Aug. 21–23 |
| 60°+27° | Nov. 2–3 |
| 60°+28° | Aug. 21–23 |
| 60°+28° | Nov. 14–17 |
| 60°+29° | Sept. 8–14 |
| 61°+28° | Feb. 4–5 |
| 60°+34° | Nov. 3–5 |
| 60°+35° | Sept. 4–5 |
| 60°+37° | Nov. 27–Dec. 1 |
| 60°+38° | Sept. 7 |
| 61°+36° | Sept. 2–6 |
| 61°+36° | Sept. 15–16 |
| 61°+37° | Nov. 29–30 |

| Position of Radiant. | Date. |
|---|---|
| 62°+34° | Nov. 12–14 |
| 62°+35° | Aug. 21–25 |
| 62°+36° | Aug. 28–Sept. 7 |
| 62°+37° | Aug. 25 |
| 62°+37° | Sept. 3 |
| 62°+37° | Sept. 8–10 |
| 62°+37° | Sept. 17 |
| 62°+21½° | Nov. 12 |
| 62°+22½° | Nov. 20 |
| 63°+21° | Nov. 27 |
| 63°+22° | Oct. 17 |
| 63°+23° | Sept. 21–22 |
| 64°+20° | Nov. 6–10 |
| 64°+22° | Sept. 17–24 |
| 64°+23° | Nov. 29–Dec. 1 |
| 65°+24° | Nov. 14–23 |
| 65°+60° | July 30–Aug. 1 |
| 69°+51° | Aug. 6–10 |
| 70°+50° | July 30–31 |
| 70°+50° | Aug. 21–26 |
| 71°+51° | Oct. 20 |
| 69°+66° | Nov. 19–20 |
| 69°+70° | Sept. 17–19 |
| 70°+65° | Aug. 10–12 |
| 70°+65° | Aug. 27–29 |
| 70°+65° | Oct. 14–20 |
| 70°+65° | Nov. 13 |
| 70°+66° | Aug. 21–23 |
| 70°+67° | Dec. 4–8 |
| 71°+61° | Oct. 13–21 |
| 70°+ 4° | Sept. 14–25 |
| 70°+15° | Nov. 27–29 |
| 72°+14° | Jan. 2–8 |
| 72°+14° | Sept. 9–19 |
| 72°+14° | Sept. 15–16 |
| 73°+14° | Sept. 7 |
| 74°+14° | Oct. 8–16 |
| 74°+15° | Aug. 29 |
| 75°+15° | Sept. 13–22 |
| 75°+15° | Sept. 27–Oct. 2 |
| 75°+15° | Oct. 19–21 |
| 72°+41° | Sept. 15–16 |
| 73°+41° | Aug. 7–22 |
| 73°+41° | Sept. 20–Oct. 2 |
| 73°+42° | Nov. 14–15 |
| 73°+43° | Sept. 12–15 |
| 73°+45° | Sept. 22 |
| 76°+44° | Sept. 21 |
| 78°+43° | Nov. 20–28 |
| 79°+49° | Dec. 8–13 |
| 76°+56° | Sept. 21–25 |
| 77°+57° | Sept. 15–17 |
| 78°+57° | Oct. 14–15 |
| 79°+56° | Nov. 15–17 |
| 75°+31° | July 23 |
| 75°+33° | Aug. 27 |
| 76°+33° | Sept. 14–21 |
| 76°+33° | Nov. 17 |
| 76½°+33° | Nov. 12–13 |
| 77°+31° | Oct. 8–16 |
| 77°+32° | Nov. 7–9 |
| 77°+32° | Dec. 22–29 |
| 78°+24° | Nov. 27–28 |
| 79°+21° | Nov. 22–26 |
| 79°+24° | Dec. 4–7 |
| 80°+21° | Oct. 8 |
| 80°+23° | Dec. 4–8 |
| 80°+24° | Nov. 12–14 |
| 80°+24° | Dec. 15–28 |
| 80°+25° | Sept. 20–25 |
| 80°+25° | Nov. 29–Dec. 8 |
| 81°+22° | Nov. 29–30 |
| 82°+75° | Sept. 14–25 |
| 84°+74° | Jan. 4–11 |
| 85°+72° | Sept. 18–22 |
| 84°—11° | Oct. 15–19 |
| 84°+10° | Oct. 16–17 |
| 85°+33° | Nov. 20 |

| Position of Radiant. | Date. | Position of Radiant. | Date. |
|---|---|---|---|
| 87°+34° | Sept. 13–18 | 88°+17° | Sept. 15–16 |
| 87°+35° | Sept. 27 | 88°+19° | Nv. 30–Dc. 10 |
| 87°+37° | Dec. 8 | (90°+14½°) | (Oct. 20) |
| 87°+42° | Sept. 25–26 | (90°+15°) | (Oct. 17) |
| 87°+42° | Oct. 11–16 | (90½°+15½°) | (Oct. 19) |
| 87°+43° | Sept. 21 | (91°+15°) | (Oct. 22) |
| 84°+55° | Oct. 5–8 | (91°+16°) | (Oct. 16) |
| 85°+53° | Nov. 20 | (91°+16°) | (Oct. 24) |
| 87°+56° | Sept. 17–19 | (91°+17°) | (Oct. 11–14) |
| (90°+58°) | (Oct. 14–25) | (92°+14°) | (Oct. 17) |
| (92°+57°) | (Dec. 31) | (92°+14°) | (Oct. 21) |
| 87°+20° | Sept. 9–19 | (92°+15°) | (Oct. 17–18) |
| 88°+17° | Oct. 17–19 | (93°+17°) | (Oct. 15–20) |

An analysis of the radiants in the remaining three quadrants of Right Ascension leads to similar results, and is only omitted because it would occupy too much space. It will be seen that nearly all the radiants observed by Mr. DENNING are reducible to a comparatively small number of certain or probable stationary or long-enduring radiants lasting, in almost all instances, more than the three weeks which Mr. GREG assigned as the average. At least twenty-five of these radiants appear to be distinctly indicated by the quadrant which I have examined. The comparatively small number of radiants which appear isolated were, in most cases, unfavorably situated for observation—as, for instance, when the radiant-point has a Southerly Declination, the observer being stationed at Bristol. The duration of the showers, it will be also noticed, is almost entirely included in the last six months of the year. The explanation of this fact is probably that radiants in this quadrant of Right Ascension are unfavorably situated for observation during the other six months, and it is very probable that the showers have in general a longer continuance, but have escaped observation for this reason. There are also instances in which showers which appear to be isolated in Mr. DENNING'S Catalogue are shown by the observations of others to have really a considerable duration. Thus, the position at 5°+17° on August 21–23 is rather too far removed from a well-known stationary radiant to be referred to it, but on reducing Italian observations Mr. DENNING obtained the same radiant

or the period May 26–June 13, and one at 5°+ 20° for August 6–10 (corresponding with a radiant of 4°+ 20° observed by himself), while SAWYER gives radiants at 2°+ 15° and 2°+ 16° for August 31–September 11, to which may be added radiants observed by HEIS, SCHMIDT and TUPMAN, giving a still longer duration to the shower. Again, it may be doubted, perhaps, whether the radiant at 3°+ 49° on July 8–11 belongs to the same cluster as the next seven in my list, but SCHIAPARELLI observed meteors from the same radiant on July 31, and TUPMAN from 5°+ 49° on August 20–29. Observations by others may also be in many cases called in to prove that Mr. DENNING's showers are not intermittent, but continuous. There is, indeed, hardly any instance in which the duration of a meteor-shower can be shown to be a short one, or in which there is any appreciable shifting of the radiant as we pass from its earlier to its later manifestations; and I think the average duration of a shower amounts to at least double the period adopted by Mr. GREG.

## SOLAR ECLIPSE, OCTOBER 20, 1892.

### TIMES OF BEGINNING, ENDING, POSITION ANGLE, ETC., COMPUTED FOR SEATTLE AND SPOKANE, WASH., AND PORTLAND, OR.

By ORRIN E. HARMON, Chehalis, Lewis Co., Wash.

| | Pacific Standard Time. A. M. | | Local Time. A. M. | | Duration. | Moon's Hourly Motion in Relative Orbit. | Position Angle North towards the East. | | Magnitude of Eclipse Sun's Diameter = 1. |
|---|---|---|---|---|---|---|---|---|---|
| | Begins. | Ends. | Begins. | Ends. | | | At Begin'g. | At End'g. | |
| SEATTLE. Lat. 47° 35′ N... Long. 8h. 9m. 20s. W..... | H. M. S. 8 36 36 | H. M. S. 10 3 26 | H. M. S. 8 27 16 | H. M. S. 9 54 6 | H. M. S. 1 26 50 | 1300.6″ | ° ′ ″ 7 33 13 | ° ′ ″ 68 30 13 | .13 |
| SPOKANE. Lat. 47° 40′ N... Long. 7h. 49m. 40s. W..... | 8 33 22 | 10 19 23 | 8 43 42 | 10 29 43 | 1 46 01 | 1262.9″ | 1 52 30 | 75 40 50 | .19 |
| PORTLAND. Lat. 45° 32′ N... Long. 8h. 10m. 52s. W..... | 8 45 11 | 9 55 10 | 8 34 19 | 9 44 18 | 1 9 59 | 1289.9″ | 14 48 46 | 62 34 52 | .08 |